# UNDERGROUND STORAGE TANK DIVISION

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| **SUBJECT: Guidance for Groundwater Corrective Action Activities at Petroleum Release Sites Utilizing Monitored Natural Attenuation** | **DATE: August 25, 1997** | **Operational Memorandum No. 13** |

**Purpose:** This operational memorandum is intended to provide guidance in determining whether monitored natural attenuation is a feasible and effective method of corrective action at petroleum release sites consistent with the requirements of Part 213, Leaking Underground Storage Tanks (LUST), of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended. The implementation of natural attenuation may include extensive site characterization, risk evaluation, long-term monitoring and modeling, as necessary. Use of monitored natural attenuation should be limited to sites where it will not pose unacceptable risks to public health or environmental receptors. ***Natural attenuation is not to be interpreted as a no further action alternative*.** Within the parameters and conditions outlined in this operational memorandum the Underground Storage Tank Division (USTD) accepts natural attenuation as a method of corrective action. Natural attenuation can be used exclusively, or in conjunction with other remediation technologies. This operational memorandum should be filed as Attachment 24 in your Guidance Document for Risk-Based Corrective Action at Leaking Underground Storage Tanks.

**Terminology:** Natural Attenuation is the reduction in mass, concentration and/or mobility of a compound in groundwater over time and/or distance from the source of contamination due to naturally occurring physical, chemical, and/or biological processes.

**Requirements:**

**Site Characterization:** Before choosing natural attenuation as the corrective action alternative for a site, the Qualified Consultant (QC) must determine that the site has the appropriate characteristics. The minimum site characterization requirements for considering natural attenuation are:

1. Plume must be fully defined.

2. If free phase product is present, an active free product recovery program has been implemented.

3. Plume must be stable, shrinking or appropriately modeled for an expanding plume to predict plume migration.

4. All receptors must be identified.

5. Water Supply Well(s)/Approved Wellhead Protection Areas:
   **Expanding Plume** - For an expanding plume where the identified receptors include water supply well(s), the point of compliance to meet the Tier 1 Risk-Based Screening Levels (RBSLs) shall be the standard isolation distance for public and private water supply well(s). This alternate point of compliance is due to the uncertainty associated with contaminant transport modeling and the lack of assurance that the Tier 1 RBSLs will

be met at the wellhead. Within an approved wellhead protection area no expanding plume is authorized. The following table identifies the isolation distance required for the categories of wells:

| Type of Well | Community Public Water Supply (Type I) | Noncommunity Public Water Supply Type II and Type III | Private Water Supply | Approved Wellhead Protection Areas |
|---|---|---|---|---|
| Isolation Distance (ft) | 2000 | 800 | 300 | No expanding plume |

**<u>Stable or Shrinking Plume</u>** - For a documented stable or shrinking plume the wellhead can be considered the receptor.

6. Contaminants must be capable of undergoing biodegradation. If contaminants are present which do not readily biodegrade, such as metals or methyl-*t*-butyl ether (MTBE), corrective action by natural attenuation may not be a suitable alternative, or may need to be supplemented with other remediation technologies.

7. Site factors must have potential for natural attenuation.

8. The projected time frame to achieve closure is justified by the RBCA evaluation, supported by documentation that no groundwater or surface water receptor will be impacted above Tier 1 RBSLs as a result of implementing natural attenuation as a corrective action. Consideration should be given to geologic and hydrogeologic conditions which may also limit other corrective actions within the same time frame.

**Plume Stability :** Plume stability should guide the level of effort for demonstration of the natural attenuation process. The monitoring requirements for a stable or shrinking plume will differ from those for migrating plumes or where plume stability is unknown. Modeling can be used to gain a better understanding for the contaminant migration rates, plume stability and compliance points for expanding plumes. Stable or shrinking plumes are defined by degradation rates that exceed the contaminant input into the plume from contaminant source(s). If the plume is expanding, modeling may be used to justify natural attenuation as a corrective action alternative considering on-site and off-site receptors and points of compliance. For guidance on groundwater modeling see USTD Operational Memorandum No. 10. Also, refer to item 5 under “Site Characterization” of this document.

**Free Product :** Part 213 requires that free product must be removed. Free product removal must be conducted in accordance with Section 21307(2), of Part 213, and USTD Operational Memorandum No. 7. In order for natural attenuation to be considered an appropriate remedy, an active free product removal program must be a prerequisite. The presence of free product may require additional interim remedial measures, if existing or future receptors have the potential for being impacted by an expanding dissolved plume.

**Corrective Action Plans :** Natural attenuation corrective action plans must meet the requirements of Section 21309a of Part 213. This includes, but is not limited to:

1. Description of the corrective action and how it is to be implemented, including a description of how that action will meet the requirements of the RBCA process.
2. Monitoring plan to confirm the effectiveness and integrity of the remedy. At a minimum the following should be identified:
   a) Number and location of wells to be monitored
   b) Monitoring frequency
   c) Parameters to be sampled
   d) Laboratory or field methods to be used
3. Explanation of any land use or resource use restrictions, if required.
4. Schedule for implementation of the corrective action.
5. Financial assurance mechanism, if required.
6. Feasibility analysis.
7. The corrective action plan shall include a contingency plan should natural attenuation not be successful. The contingency plan may specify a technology(s) that may be different from the selected remedy or the existing remedy may be modified and/or enhanced. It is recommended that one or more criteria (“triggers”) be established to signal the implementation of contingency measures. Such criteria may include the following:
   - Contaminant concentrations in specified wells exhibit an increasing trend;
   - Near-source wells exhibit large concentration increases indicative of a new or renewed release;
   - Contaminants are identified in sentinel wells located outside of the original plume boundary;
   - Contaminant concentrations are not decreasing at rates sufficient to meet the remediation objectives;
   - Changes in land and/or groundwater use will adversely affect the protectiveness of the monitored natural attenuation remedy;
   - In establishing triggers or contingency remedies, seasonal fluctuations should be evaluated.
8. Any corrective action that does not result in unrestricted use of off-site properties below Tier 1 residential RBSLs requires public notice as described in Section 21309a (3).

**Monitoring:** Performance monitoring is a critical element of all long-term response actions necessary to evaluate plume stability, compliance concentrations and assess remedial progress.

The demonstration of remediation by natural attenuation may include primary, secondary, and optional lines of evidence. At a minimum, primary lines of evidence are required to demonstrate the effectiveness of natural attenuation. The decision to collect secondary and optional lines of evidence should be based on the intended use of the data. The cost benefit of obtaining these lines of evidence should also be considered. For sites which have sufficient historical monitoring data, the primary lines of evidence will often be adequate to demonstrate remediation by natural attenuation.

<u>Primary lines of evidence</u> for evaluating natural attenuation is the reduction in plume geometry and BTEX concentrations. For those plumes where the quantity and quality of BTEX data is

adequate, the primary lines of evidence will often be sufficient for evaluating the effectiveness of natural attenuation as a corrective action alternative.

Secondary lines of evidence include geochemical indicators of naturally occurring biodegradation and estimates of natural attenuation rates. If the primary lines of evidence are inconclusive, it may be necessary to obtain secondary lines of evidence. These secondary parameters may include dissolved oxygen, dissolved iron, nitrates, redox potential and pH. It may be difficult to collect reproducible data for these parameters. Variability can be introduced by purging techniques, instrumentation and operators. For this reason, when these samples are collected, they should only be used for qualitative evaluations. Once these secondary lines of evidence have been established, the user must continue to monitor and collect data to substantiate the primary lines of evidence.

Optional lines of evidence may be used to more rigorously interpret data developed as secondary lines of evidence, particularly if the primary and secondary lines of evidence are inconclusive to demonstrate remediation by natural attenuation. Optional lines of evidence include solute transport modeling, estimates of assimilative capacity (to estimate the mass of BTEX and other constituents of concern degraded), and microbiological studies.

Proper monitoring is essential for the acceptance of natural attenuation as a corrective action. Monitoring should demonstrate that natural attenuation is effective and is protective of public health and the environment. Figure 1 is an example of a hypothetical sampling strategy.

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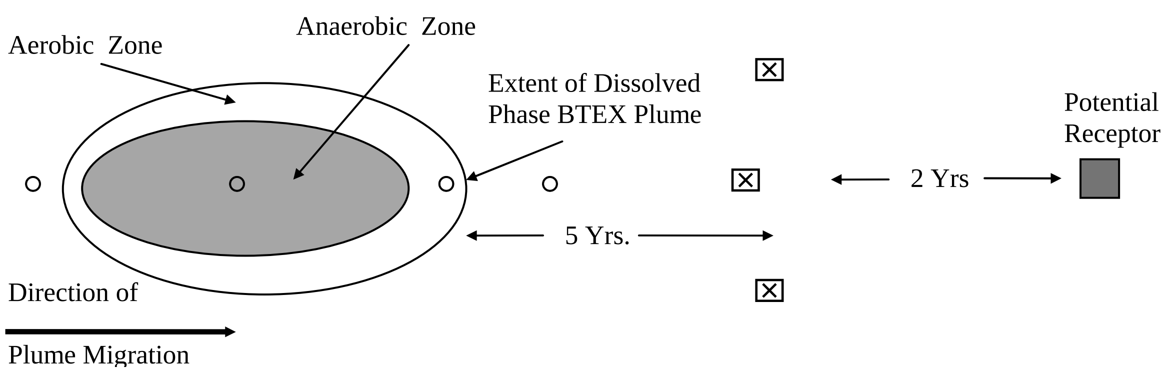
**Figure 1**

**HYPOTHETICAL LONG-TERM MONITORING STRATEGY**




**LEGEND**
**☒- Point-of-Compliance Monitoring Well**
**○ - Long-Term Monitoring Well (Not To Scale)**

The monitoring layout in Figure 1 assumes that sufficient information has been gathered to adequately predict contaminant transport. The long-term monitoring wells are placed upgradient, within, and immediately downgradient of the contaminant plume. These wells are used to monitor the effectiveness of natural attenuation in reducing the total mass of contaminant within the plume and the aerobic and anaerobic indicators associated with the natural biodegradation process. The actual number of wells required at a site depends on site conditions.

A minimum of four wells are required, one upgradient of the contaminant plume, one within the anaerobic treatment zone, one in the aerobic treatment zone, and one immediately downgradient of the contaminant plume. Lateral wells may also be necessary depending on site conditions. The monitoring plan should allow adequate travel time from the source to the receptor so that alternate means of remediation may be employed if necessary.

Point-of-Compliance (POC) monitoring wells are wells that are installed at locations downgradient of the contaminant plume and upgradient of potential receptors. The POC monitoring wells are generally installed along a downgradient property boundary or at a location to verify the model predictions given the groundwater velocity, or one (1) to two (2) years upgradient of the nearest downgradient receptor, whichever is more protective. Refer to the table under "Site Characterization" item 5 of this document for POC isolation distances from water supply wells.

It is recommended that plume stability and location of receptors be used to establish an appropriate monitoring plan:

<u>Stable/shrinking Plumes (based on historical data):</u>

- Use existing BTEX data (primary lines of evidence)

<u>Plume Stability Unknown or Migrating Plume:</u>

- Collect indicator parameters for qualitative indications of natural attenuation. (secondary lines of evidence)
- Use simple analytical model to calculate time to reach plume stability and plume length when stability is achieved.

Indicator parameters may include one or more of the following:

1. <u>Individual hydrocarbon components</u> - can be performed using standard techniques and provides an indication of the effectiveness of the natural attenuation process.
2. <u>Dissolved oxygen (DO)</u> - is monitored to determine extent of aerobic biodegradation and as an aid in defining the contaminant plume. Dissolved oxygen must be measured in the field using DO meters or field test kits.
3. <u>Nitrate and dissolved iron</u> - may be monitored to determine the extent of anaerobic biodegradation of the hydrocarbons and any bacterial waste products. Nitrate may be monitored by collecting samples using conventional techniques and then transporting to the laboratory for analysis. Samples collected for iron analysis should be field-filtered and preserved with acid to prevent suspended solids from dissolving and to prevent dissolved iron from being precipitated during transport.
4. <u>Redox potential</u> - is a good indicator of the overall oxidation - reduction status of the aquifer. Redox potential can be measured using a platinum electrode and a standard pH meter. In locations where the redox potential is negative, the groundwater is strongly reduced, indicating potential anaerobic biodegradation. If the redox potential is positive, the groundwater is likely to be aerated, indicating significant aerobic biodegradation potential.
5. <u>pH</u> - If pH falls outside of a specified range (typically 5 to 9), biodegradation may be inhibited.

**Sampling Schedule :** The recommended minimum sampling schedule for a stable or shrinking plume would include quarterly sampling and analyses for the first two (2) years, semiannually for the next two (2) years, and yearly thereafter or until closure verification requirements are achieved.

Monitoring schedules may be altered based on the sampling history of the site, contaminant concentrations and/or degree of confidence in the computer modeling. In a case where there is multiple years of monitoring and plume stability is certain, the schedule may be altered based on agreement with the USTD project manager. Groundwater modeling may be used to determine a site specific monitoring schedule considering groundwater velocity and rate of plume migration. The above schedule assumes that natural attenuation is occurring at predicted rates.

**Financial Assurance:** The financial assurance requirements may need to be addressed as part of the Corrective Action Plan as provided for in Section 21309a(2)(f) of Part 213. The amount of financial assurance needs to be approved by the USTD, and should be equal to the cost of an alternate remediation option as detailed in the feasibility analysis. Financial assurance may not be required, if the contaminant plume is stable or shrinking and is not projected to migrate off-site.

This memorandum is intended to provide guidance to QCs and USTD staff to foster consistent application of Part 213. This document is not intended to convey any rights to any parties, nor create any duties or responsibilities under law. This document and matters addressed herein are subject to revision.

Questions concerning this operational memorandum should be addressed to the appropriate USTD project manager or District Supervisor at the district office responsible for the area where the site is located.

Periodic review and revisions to this operational memorandum are the responsibility of the Chief of the Field Operations Section.

| Authorization: | Date: |
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Distribution: Qualified USTD Consultants
USTD Mailing List
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USTD Supervisors

**References :** Sources available that have information on natural attenuation included:

***In-Situ Bioremediation of Groundwater and Geological Material: A Review of Technologies, EPA document*** EPA/SR-93/124,

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Wiedemeier, Todd H., Wilson, J.T., Kampbell, D.H., Miller, R.N., Hansen, J.E., 1995, ***Technical Protocol for Implementing Intrinsic Remediation with Long-Term Monitoring for Natural Attenuation of Fuel Contamination Dissolved in Groundwater,*** Report by Parsons Engineering Science, Inc., for the Air Force Center for Environmental Excellence, Fall 1993, Volumes I and II.